DOCUMENT RESUME

ED 114 297 SE 019 990

AUTHOR	Helgeson, Stanley L.
TITLE	Impact of the National Science Foundation Teacher Institute Program. Minnesota Research and Evaluation Project. Research Paper No. 16.
INSTITUTION	Minnesota Univ., Minneapolis. Coll. of Education.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	RP-16
PUB DATE	Dec 74
NOTE	58p.
AVAILABLE FROM	Minnesota Research and Evaluation Project, College of Education, University of Minnesota, Minneapolis, Minnesota 55455 (free while supply lasts)
EDRS PRICE	MF-$0.76 HC-$3.32 Plus Postage
DESCRIPTORS	Attitudes; Higher Education; *Inservice Programs; *Inservice Teacher Education; *Institutes (Training Programs); Research Reviews (Publications); *Science Education; Science Teachers; Teacher Behavior; Teacher Education
IDENTIFIERS	Minnesota Research and Evaluation Project; *National Science Foundation; NSF; Research Reports

ABSTRACT

Focused on the impact of the institute program for inservice teachers sponsored by the National Science Foundation, this report summarizes the findings of 138 documents (research and evaluation studies). Documents reviewed were grouped into dissertations and theses (63), journal articles (41), interim or final reports (23), papers presented at professional meetings (9), and books (2). Information contained in these documents was summarized in terms of six subcategories: Characteristics of Participants, Subject Matter Competence, Teacher Attitudes, Teaching Behavior, Understanding of Science, and Career Effects. Examples of studies fitting into each of these categories were selected for illustrative purposes. In addition to the discussion provided for each of the subcategories, a four-page summarization is also included. (PEB)

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RESEARCH PAPER #16

Impact of the National Science Foundation Teacher Institute Program

Stanley L. Helgeson
The Ohio State University

December 1974

This study was supported by Grant GW-6800 from the National Science Foundation to the University of Minnesota; Wayne W. Welch, Project Director.

IMPACT OF THE NATIONAL SCIENCE FOUNDATION TEACHER INSTITUTE PROGRAM

Stanley L. Helgeson
The Ohio State University
Columbus, Ohio 43210

INTRODUCTION

Over the past two decades the National Science Foundation has sponsored hundreds of institutes attended by thousands of classroom teachers and administrators. That these institutes have had a beneficial impact upon education seems widely accepted by participants, principals and administrators, college personnel and educational observers (65). There has been less agreement, however, about the precise nature of this impact, stemming in part from the different kinds of research and evaluation studies of the various institutes.

The citations included should be considered representative of studies conducted rather than an exhaustive bibliography. Table 1 presents a categorical breakdown of the 138 documents reviewed. As is the case in most educational research, the majority of the studies, 64, were in the form of theses or dissertations. Many of these, however, were follow-up studies of long term evaluations extending beyond a single year in scope. Approximately one third of the studies were reported as journal articles, accounting for 41 of the documents. Twenty-three documents were categorized as reports, most of which were interim or final reports to NSF. Finally, there were nine presented papers and two books included. In a few cases two citations are included which resulted from the same study. In these instances the intents and emphases were different, hence the duplication.

TABLE 1

Types of Documents Reviewed

Dissertations and Theses	63
Journal Articles	41
Reports	23
Presented Papers	9
Books	2
TOTAL	138

Much of the research was of a descriptive nature dealing with characteristics of the institute participants, their attitudes, various aspects of the programs or changes in teaching behavior perceived by students, principals or the teachers themselves. Several studies were concerned with changes in the teachers' subject matter competence. Relatively few studies dealt with the impact upon students of the institute participants. Those that did tended to emphasize student achievement, attitudes, and understanding of science.

Rather than reviewing in detail each of the studies, examples will be selected for each of the general categories. Results and findings will be summarized and synthesized in an attempt to derive some general conclusions about the effectiveness of the NSF institute program. Because most of the studies were multifaceted, many will be cited in more than one category. For the present purpose, major emphases will be placed on the impact on elementary and secondary school science teachers as a result of their participation in the Institute Program and on the impact on students of such teachers. Although occasional reference will be made to curriculum change, development or implementation, much of this information has been summarized elsewhere [Howe (54), Schlessinger, et. al. (108), Maben (71), Nelson (85), Webb (128)] and will not be presented in detail here.

IMPACT ON TEACHERS

Prime concerns of the NSF institutes, particularly in the early years, were to upgrade the backgrounds of the teachers and to bring about a change in the way science was taught in the schools. It is not surprising, then, that the majority of the studies were concerned with the teachers as participants in various institutes, their characteristics, and the upgrading of their content backgrounds. Studies dealing with the various teacher-participant factors will be summarized in the six subcategories: Characteristics of Participants, Subject Matter Competence, Teacher Attitudes, Teaching Behavior, Understanding of Science, Career Effects.

Characteristics of Participants

Virtually every study contains some information with respect to the participants. Rather than compiling a listing of the various factors included, it appears more useful to examine certain of the studies to determine, in general, 1) characteristics of institute participants, 2) differences between acceptees and rejectees among applicants to institutes and, 3) differences between applicants and non-applicants.

Dzara (31) investigated certain aspects of NSF summer institutes held at the University of Alabama from 1957-1962. One hundred nineteen of the 130 participants responded to the questionnaire. He found that the age range of the participants was from 23 to 59 with more than 80 percent under 50 years of age. Participants had from one to 37 years of teaching experience with eighteen teaching majors represented based upon undergraduate preparation. Using earned credits as the criterion, Dzara found that the majority were inadequately prepared to teach science although 49.4 percent held the Master's degree.

In a series of studies, Flesher, et. al., (33, 34, 35, 36, 37) examined the nature of the participants and program for four Academic Year Institutes at The Ohio State University from 1957 through 1961. Of the 204 participants, 41 were women; the 4 to 1 ratio remained essentially constant over the four years. The ages of the participants ranged from 23 to 54 years with the median approximately 32 years. Although the percentages varied from year to year, approximately 80 percent of the total number of participants were married. Teaching experience possessed by the applicants ranged from 2 to 30 years with the median at approximately 6 years. Eighty-eight participants, approximately 43 percent, held both Bachelor's and Master's degrees, while 116 held only the Bachelor's degree. Most of the undergraduate majors were in the area of science. Areas of preparation with approximate median credit hours were biology, 24; chemistry, 16; physics, 11; earth science, 5; mathematics, 15; and education, 34. The number of teaching fields varied from one to five with approximately 70 percent teaching in one or two fields.

In a study of characteristics and opinions of participants at NSF Academic Year Institutes held at the University of North Carolina at Chapel Hill during 1968-1971, Macon (72) found results very similar to those in other studies. In the category of personal data he reports a male-female ratio of 7.5 to 1; a married-single ratio of 2.7 to 1; and an average age of 31.6 years. In the area of professional characteristics he notes that 2.8 percent held Master's degrees, 76.5 percent were biology majors (the institutes were in the biological sciences), the average undergraduate biology credit was 32.6 hours, and that 9.7 percent were deficient in certification. He also found that 22.2 percent held membership in NSTA. This last indicates a finding common among other studies that participants were more likely to be members of professional associations than were non-participants.

In a study of selection procedures and prediction of success for NSF Academic Year Institutes, Dorsey (29) collected data from participants at 24 institutions which had AYI programs in 1966-67. He found that various NSF-AYI programs did use different criteria for selecting candidates. In examining possible predictors for success in the institutes he found the best cognitive predictors were undergraduate grade point average, Graduate Record Examination score, and number of hours of chemistry. The Edwards Personal Preference Schedule dimensions of Order and Heterosexuality were the best noncognitive predictors. It is interesting to note that the Heterosexuality dimension was found in a study of the characteristics of physics teachers by Rothman, Walberg and Welch (102) to be the single teacher variable related to the most measures of student learning; students were most likely to exhibit growth in understanding of science, achievement in physics, and knowledge of the processes of science. While the two studies dealt with different populations, the findings suggest the possibility that those factors which predict success for the teacher as an institute participant may be factors which promote cognitive success by students.

Jorgenson (61) studied the characteristics of teachers applying to Academic Year Institute programs at Oregon State University from 1957 through 1962. The sample included all acceptees and a randomly selected half of the rejectees. Considerable variation in characteristics existed when comparing applicants from one year to another. Acceptees and rejectees were different on the basis of undergraduate science grade point average, undergraduate science credits, science major, teaching residence, teaching experience, and membership in state and national science organizations and membership in the National Science Teachers Association. In terms of the American Association

for the Advancement of Science guidelines, many applicants were lacking in depth and breadth of science and mathematics preparation.

Berger and Berger (10) report a study of attributes of applicants to NSF summer institutes in 1964 in which they compared acceptees and rejectees. Personal characteristics such as age, citizenship, marital status, number of dependents and allowance requests, and city, state, or region of residence did not appear, in general, to have influenced selection. Educational background, however, did appear to be a factor. A fairly consistent finding was that the greater the total number of undergraduate or graduate credits in the various sciences, the greater the probability of being selected. In some cases undergraduate credits in chemistry and graduate credits in biology, physics, and earth science appeared to favor selection. Undergraduate grades appeared to be a strong factor. Acceptees usually had higher grades than did rejectees and, for most groups, these differences were statistically reliable. Graduate grades did not appear as strong a factor as did undergraduate grades but did indicate the same trend. Applicants to secondary or college institutes whose undergraduate preparation emphasized science or mathematics appeared to have a significantly better chance of being selected if their preparation was largely in educational methods. The major for advanced degrees appeared not to be a factor in selection. Professional experience including teaching a specific subject seemed to be favored at several institutes, however, the subject (biology, chemistry, physics, mathematics, earth science, or general science) varied. Teaching predominantly science or mathematics during the five years preceeding application generally increased acceptance. Finally, other professional interests such as journal reading and membership in professional organizations seemed to have some relationship to acceptance or rejection.

Differences between applicants and non-applicants to NSF institutes were studied by Orr and Young (90). On a nationwide basis, 55 percent of all science and mathematics teachers had not applied to an NSF institute, 13 percent had applied and been rejected, and 32 percent had attended at least one institute. Of the personal factors such as age, sex, and marital status, only sex appeared to be related to application to institutes with a larger percentage of men than women applying. In general, applicants had a greater total of graduate hours than non-applicants and there was a larger percentage of applicants than non-applicants with science and mathematics majors at both the undergraduate and graduate levels. A greater percentage of non-applicants than applicants had majors outside of science and mathematics education and non-applicants taught a greater percentage of non-science subjects than did applicants.

Orwick (91) in a study of high school teachers participating in NSF institutes in North Carolina investigated, among other things, differences between eligible applicants and eligible non-applicants in a six County area in North Carolina. Of the 119 respondents to his questionnaire 86.6 percent were eligible for NSF institutes. Of those eligible, 64.1 percent had participated in at least one NSF institute, 16.5 percent had applied and been rejected, and 19.4 percent had not applied. He found that science teachers who had applied for NSF institutes and science teachers who had not applied differed appreciably: applicants averaged more semester hours in undergraduate and graduate science course work than non-applicants; non-applicants averaged more semester hours in undergraduate and graduate education courses; a larger percentage of applicants held Master's degrees; a larger percentage of applicants had future plans for a graduate degree, a larger percentage of

non-applicants taught 60 percent or more non-science subjects; applicants read more professional journals; and, a larger percentage of applicants than non-applicants had attended summer school each of the past five years. Differences found between acceptees and rejectees among the applicants were generally similar to those already indicated for other studies.

Other studies related to characteristics of participants include Bartlett and Edgerton (6), Gibney (43), Heideman (49), Jax and Merrill (60), Kastrinos (62), Koelsche (64), Nixon (38), Sea (110), Slawson (114), Yegge (1[illegible]), and Yegge, et. al. (136).

The studies reviewed and cited were conducted in various parts of the country with differing participant populations and utilizing different procedures for data collection and analyses. In spite of these variations, the results appear fairly consistent for many of the characteristics examined. While this is encouraging in terms of generalizing the findings, it points to at least one disheartening conclusion. The participants tended to be those teachers who had better grade point averages, more science preparation (although this may in itself have been deficient in some cases), more teaching responsibility for teaching science, more interest in further education, and more interest and activity in professional organizations. In short, those persons most likely to be institute participants were those who were already, on these scales at least, the better qualified. Hence it appears that the gap between the better and the lesser prepared tended to be widened. It should be noted, however, that the non-applicants and rejectees were more likely to leave teaching than were the participants thus mitigating the disparity of impact.

Subject Matter Competence

When the National Science Foundation was established in 1950 it was charged with developing a national policy for the promotion of basic research and education in the sciences. In accord with this charge, conferences were held to explore ". . . the singular importance of the high school teacher's subject-matter problem and the feasibility of NSF's establishing programs designed to alleviate this problem . . ." Since that time over 470,000 opportunities for training have been offered. The results have been likened to the classical "before" and "after" advertisements. With respect to biology teachers, early institute participants were of the general science type whereas today's teacher of high school biology is typically a single discipline instructor (Adams, 1). That such improvement is not limited to biology teachers can be seen from many studies.

Gibney (43) evaluated the 1970 summer institutes for secondary school teachers of science and mathematics. Based upon 4,476 returned questionnaires, he found that the participants perceived that inservice education would best serve to bring about classroom improvement. What this inservice education should entail, however, varied with the kind of institute the participants had attended. Of those attending non-implementation institutes, most stressed updating the teacher's subject matter backgrounds and in-depth teacher education. One indication of success may be inferred from the fact that two-thirds of the participants reported implementing new curriculum materials in their classrooms following institute participation.

Brekke (16) reported the results of evaluations received from participants who attended NSF institutes at the University of North Dakota from 1957 through 1962. Data were collected from approximately half of the 277 former institute

participants, from principals of 70 high schools to which institute teachers returned, and from 29 principals of high schools which had no institute-trained teachers. Nine out of ten participants rated their growth as more than moderate (one a five-point scale) in the area of strengthened science and mathematics background. High school principals of institute participants rated the extent of the teacher's improvement as moderate or greater than moderate in 84 percent of the cases. More than 60 percent of the principals rated the teacher's gains as more than moderate following return from institutes for 1) efforts to obtain and improve science and laboratory facilities and equipment, 2) all around teaching ability and effectiveness, and 3) added subject matter competency. It was found that more students taught by institute participants went on to elect college courses in science and mathematics areas after the teacher's institute experiences than before. The teacher's increased subject matter competency was rated as being the major factor in his increased ability to motivate students toward such careers.

Welch and Walberg (133) evaluated four summer institutes for physics teachers. One hundred sixty-two teachers were tested with a pre-post-test battery of instruments which included the Test on Selected Topics in Physics (TSTP), the Test on Understanding Science (TOUS), and the Welch Science Process Inventory (SPI). Significant gains occurred on TSTP for each of the institutes indicating an increase in subject matter competency. Significant gains on TOUS were found for teachers at three of the four institutes suggesting success in increasing understanding of science and scientists. Finally, positive gains were found for all institutes on SPI, however, only the mean gains at two of the institutes were significant. It was concluded that, to the extent to which the instruments reflect the objectives of each of the four summer institutes, a change in subject matter competency was effected.

In evaluating an inservice program for earth science teachers, Mayer, Disinger and White (76) assessed, among other things, the effects of the program on participant knowledge of earth science facts and concepts. A pre-post-test of an instrument designed to reflect achievement in the behavioral objectives stated in the Teachers Manual for Investigating the Earth was administered to 20 participants. The gains were significant, suggesting that the program was successful in accomplishing this objective.

Similar results were reported by Ost (93) who found that participants significantly increased in their ability to perform operations of science after attending the institute. Ostlund (49) also reported significant increases in achievement test scores for participants following attendance at an Academic Year Institute. With elementary school teachers as subjects, Fowler (39) reported significant gains on the Read General Science Test. Selser (111) found that science teachers who had attended an institute, when compared with control teachers who had not attended the institute, made significantly higher scores on the Sequential Test of Educational Progress and on the Test on Understanding Science indicating gains in understanding of concepts of science and of the nature of science.

LaShier (66) assessed the effectiveness of a Science - A Process Approach Cooperative College-School Science Project involving 30 teachers and 5 administrators. He found that the participants exhibited significant pre- to post-measure gains in competency based on the Science Process Measure for Teachers.

Other studies dealing with subject matter competence include Berger (9), Bingham (11), Bradberry (14), Brandou (15), Brittain and Sparks (19), Bruce and Parakh (22), Dzara (31), Exline (32), George and Rose (42), Gray (44),

Highwood and Mertens (52), Irby (56), Jenkins (59), McCormick (77), McCurdy (78), Menesini (79), Nicodemus (86), Ost (92), Ostlund (95), Passero (97), Redburn (100), Selser (111), Slawson (114), Spradlin (116), Sutherland (118), Tweeten (123), and Ward (127).

With respect to changes in teachers' subject matter competence related to the NSF Institute Program, there is greater agreement than in any other area. Nearly every study and document reviewed indicated that in this area the Institute Program was clearly a success.

Teacher Attitudes

Studies related to teacher attitudes ranged over a broad spectrum including considerations of attitudes toward certain curriculum materials, toward science, and toward teaching.

Ost (93), in evaluating an institute for teachers of secondary school bioloty, tested the hypothesis that there would be no difference in the attitudes of the participants towards BSCS materials and rationale before, and after attending the institute. The Biology Teacher's Attitude Inventory was mailed to the participants before and six months after the institute. A t-ratio for correlated means was calculated for the scores on the Inventory and found to be significant. It was concluded that the attitudes of the participants towards BSCS materials and rationale did improve after attending the institute.

The evaluation of a leadership workshop on elementary school science reported by Merkle (80) focused, in part, on changes in knowledge of and attitude toward AAAS and SCIS elementary school science curricula, and on the effects of various aspects of the workshop activities on the attitudes of the participants. He found that participants' pre-post-test gains in knowledge

of program characteristics and program implementation procedures were significant and that the participants also exhibited a significant positive change in attitude toward the programs from pre-test to post-test. However, participants scores on attitudes toward the workshop were not found to be significantly related to the participants knowledge of program characteristics, program implementation procedures, or attitudes towards the programs.

Chapman (25) investigated the effects of a six week summer institute on elementary school teachers' attitudes toward science and their understandings about the scientific enterprise, scientists, and the methods and aims of science. The experimental group consisted of teachers participating in the institute and the control group of randomly selected elementary school teachers in other summer session classes. Both groups given the Test on Understanding Science and the Dutton Attitude Toward Science Scale at the beginning and close of the summer session. The experimental group showed a significant gain on pre-post test scores on TOUS and significantly greater change in post-test scores compared to the control group. However, the experimental group did not show a significant change on the Dutton Attitude Toward Science Scale nor was a significant relationship found between attitude toward science and understanding of science as measured by these instruments.

Rather similar results were found by Simmons (113) in a study of elementary teachers involved in SCIS workshops. A semantic differential instrument was utilized in a pretest-posttest mode to evaluate, in part, teacher attitudes toward elementary science. The data failed in nearly all instances to reveal any major attitude differences between the experimental and control sample.

Irby (56), in a followup study of AYI participants at the University of Missipsippi from 1961-1966, gathered data on 151 secondary school mathematics

and science teachers. Among other conclusions, he noted that the professional attitude of teachers who had attended an institute was improved.

Brekke (16) reported on a similar follow up study for participants who attended NSF institutes at the University of North Dakota. With respect to attitudinal changes he concluded that major desirable changes fostered by institute attendance were an increased enthusiasm for teaching science and mathematics and a desire to gain a graduate degree through further study.

Rothman, Walberg and Welch (102) studied changes in teachers' attitudes toward physics and towards several activities related to the teaching of physics. Fifty-six teachers were randomly selected from a national population of approximately 17,000. Thirty-six of these teachers participated in a summer institute while the remaining 20 served as the control group. No overall significant difference was found on the "student activities" scores, leading to the conclusion that teachers' attitudes related to these activities were not affected by the summer institute. It was found, however, that the teachers in the experimental group rated science as more understandable and physics in their lines as less complex and also rated science as more important but physics less important. From these findings it appeared that the factual content had been effectively presented.

Zurhellen (138) evaluated attitude changes among science teachers during an ESCP inservice institute. The population consisted of 75 teachers and 20 leaders who attended the introductory sessions and were involved in the year long program. No significant changes in attitudes on the part of the leaders was found. However, there were significant attitude changes exhibited by the teachers in the areas measured by the Minnesota Teacher Attitude Inventory and the Teaching Situation Reaction Test and in areas of My Ideal Teacher,

My Ideal Student, and My Ideal Self measured by a Semantic Differential Scale. The pattern of shift in attitude scores was positive across the August session, negative from August to January and mixed from January to April. This indicated the possible harmful effects of long-term inservice programs and suggested the efficacy of several short-term concentrated work sessions.

Other studies related to teacher attitudes include Dean (28), Gruber (45), Hassard and Smith (48), Heideman (49), Horner (53), Hulleman (55), Jenkins (59), Nicodemus (86), Parker (96), Sarner and Edmund (106), Spradlin (116), Sutman (119), and Yegge, Watson and White (136).

The results of studies reviewed in this area do not readily suggest clear cut conclusions with respect to specific conditions. For example, increased knowledge about a program did not always appear to be related to a change in attitude towards that program. The results do suggest, however, the general conclusions that positive attitude changes could be, and were, brought about and that the institutes appeared to be significant factors in these changes. The permanence of these changes remains a partially answered question although follow up studies after time lapses of one to five years often found attitudes of participants to be markedly positive, particularly toward the institutes as experiences beneficial to the participants.

Teaching Behavior

In order to bring about change in science education it was determined that not only was updating of the teachers' background necessary, but the way in which science was taught needed to be altered (Kreighbaum and Rawson, 65). The degree to which this objective was accomplished was a facet of many of the reported evaluations.

Anderson and Horn (4) assessed a model for the diffusion of the new elementary school science curricula. The model, funded through the Cooperative College-School Science Program, employed a limited number of personnel to promote diffusion on a large scale basis. One of the first major concerns was to determine whether the teachers' style of teaching changed as a result of participation in the project. Twenty-eight teachers were randomly selected from approximately 150 teachers as a group from which pre-test data could be acquired and a different set of 28 were selected as the source of posttest data. Changes in teaching style were assessed through observation and the use of the Teaching Strategies Observation Differential (TSOD). This instrument provides an overall rating of the style of teaching employed by a teacher on a continuum with expository-direct and inductive-indirect representing the extremes. All teachers were provided with the same materials for use during the class scheduled for observation and a 20-30 minute segment of teaching was videotaped prior to the inservice classes. After completion of the inservice classes, a similar sample of teaching was recorded for the other selected group of teachers. The samples were rated by a group of four raters following a randomly determined pattern of rating. The average Hoyt interrater reliability was .94. The gain from pretest to posttest was significant at the .01 level. The investigators concluded that the

one semester inservice course had produced a change in the teachers' style of teaching.

In a study of an NSF summer institute conducted at Ball State University, Hendren, Mertens and Nisbet (50) investigated the usefulness and degree of implementation of 55 specific topics included in the institute. Prior to the institute each participant was asked to assess the emphasis he had placed on each topic during the preceeding school year and to indicate, on a 1-7 scale, what emphasis he desired to place on each of the 55 topics in the future. On the last day of the institute each participant was again asked to assess the level of attainment he wished to achieve for each topic during the school year. At the end of the following school year each teacher assessed what he actually accomplished during the school year. The data suggested that the institute was effective in motivating the participating teachers to increase in their own teaching the level of emphasis given to 45 of 55 instructional topics stressed in the institute.

Berger (9) compared groups of teachers of elementary school science on their predicted behaviors in order to study the influence of NSF teacher training institutes for and experience with the Science Curriculum Improvement Study (SCIS) teaching strategies. The groups selected included 51 teachers not exposed to SCIS, 69 teachers not exposed to SCIS but starting an SCIS institute, 76 teachers who had completed an NSF institute in the SCIS program, and 45 teachers who had completed a four week institute and had taught the SCIS curriculum for at least one year. The groups of teachers were compared using the Predicted Role Measure which involved a film of elementary school classroom scenes and a response sheet. When the teacher in the film was to make a decision, the film was stopped and the participants

were asked to respond by rating their agreement to behaviors they might exhibit if they were the teacher in the film. The responses were scored and the scores separated into three categories which were essentially 1) a teacher-oriented score, 2) a student-teacher cooperation score, and, 3) a student-oriented score. The Predicted Role Measure reflected a variety of situations, was specific enough to provide common input, reflected actual teaching decisions rather than broad attitudes, and it reflected and discriminated between the differing teaching behaviors described by the SCIS curricula. Split-halves reliability was established at 0.84 and a comparison of predicted behaviors to actual observed classroom behavior established a validity of 0.74. In general, there was a positive correlation between experience of teachers with the SCIS program and their degree of agreement with the SCIS criteria judging group. There was no significant difference between the scores of the 51 no-SCIS instruction group and the 69 pre-instruction group as measured by multivariate analysis of variance. There was a significant difference between the scores of the pre-institute teachers and the post-institute teachers. Post-institute teachers were less teacher-oriented in their scores than were pre-institute teachers. Post-institute teachers and post-institute teachers with one year experience teaching SCIS did not differ significantly in their scores. It was also determined that there was no overall significant relationship between the background variables of age, sex, years of teaching experience, grade level taught, enjoyment of teaching science, number of years of college science, and number of science methods courses and the scores on the Predicted Role Measure. It was concluded that teachers who experienced the NSF institutes and/or taught the SCIS curriculum changed their predicted teaching behaviors in the direction of the SCIS staff judging group.

Bridges, Bingham and Green (18) evaluated the Cooperative College-School Science Improvement Program to prepare teachers to teach the DISCUS program. To determine whether there were differences between teachers who were trained and those who were not, videotapes were made in classrooms of both trained and untrained teachers. The tapes were analyzed using the Teacher Practices Observation Record (TPOR) and the Reciprocal Category System (RCS). It was postulated that if the class atmosphere was success-oriented, analysis of a videotape should show it to be more in harmony with the basic philosophical set of the DISCUS materials which would be in accord with Dewey's "Experimentalism" and less "Authoritarianism" in nature. The investigators found that teachers trained for the program did operate in the classroom more in harmony with the "experimentalism" philosophy than did the non-trained teachers. The trained teachers also provided more active student involvement, less external disciplinary control, and more student-centered instruction. Differences in teaching methods were apparent with groups taught by trained teachers showing more student-directed, teacher-guided activity and more often using the inquiry method of instruction. It was concluded that the results clearly supported the training program.

Spradlin (116) reported a study to determine whether increased subject matter knowledge and exposure to new teaching strategies in a special Institute Program would effect any change in the classroom behavior of an inservice teacher. The sample included 50 science teachers who had participated in a Summer Institute Program at the University of Texas at Austin in 1971 and their 1240 secondary school students. The study used a one group pretest, posttest research design. Prior to the end of the 1970-71 school year, one class for each participant was given the Science Classroom Activity Checklist and a Student Semantic Differential. Pre-institute measures taken

for the teachers included a Teacher Semantic Differential (TSD), a Teacher Concern Statement (TCS), NSTA's Annual Self-Inventory for Science Teachers, and content tests for earth science, biological science, and physical science. All measures were repeated following the next year. The results indicated, among other findings, that participation in the Summer Institute Program worked to improve the teachers' classroom behavior patterns, perception of self as a professional person, their level of teaching concerns to more student centered ones, and increased their content knowledge.

Additional studies dealing with changes in teaching behavior include Adams (1), Amend (3), Brekke (16), Browne (21), Bruce and Parakh (22), Frantz (40), Flores (38), Gardner (41), George and Rose (42), Gruber (45, 46), Gruber, Brady and Means (47), Highwood and Mertens (52), Hassard and Smith (48), Heideman (49), Jackson (58), Jenkins (59), Klimas (63), LaShier (66), Marshall (73), Mayer, Disinger and White (76), Merkle (80), Ost (92, 93), Nicodemus (86, 87), Parker (96), Redburn (100), Petrongolo (99), Sarner and Edmund (106), Simmons (113), Schmidt (109), Sutman (119), and Thompson (122).

The preponderance of evidence presented in these studies indicates that teaching behavior in most instances did change following the teachers' experiences in the various institute programs. Moreover, these changes tended in general to be in the directions desired by the institute organizers. The changes were perceived positively by the teachers themselves, by their students, and by their supervisors. While factors other than institute participation cannot be excluded in all cases, it seems eminently reasonable to conclude that the institutes were significant causative agents in promoting improved teaching. It does not necessarily follow, however, that such improvement remains a permanent condition.

Understanding of Science

The relationship of the Institute Program to the participants' increased knowledge and subject matter competence has already been summarized with respect to a discipline-oriented perspective. The broader concern of teachers' increased or changed understanding of the nature of the scientific enterprise with respect to the methods and processes of science was also reflected in a number of studies.

Wittwer (134) reported the evaluation of a Research Participation Program (RPP) at the University of Wisconsin. Among the objectives evaluated were the extent to which the program had provided activities and responsibilities meaningful in terms of research in science or mathematics; had enabled the participants to generate tangible research results; and, had developed in the participants understanding of the methods or processes of science. Based upon opinions of the supervising professors, more than 90 percent of the RPP teachers gained a feeling or understanding of the real nature of research. Also, in the opinions of the supervising professors, nearly half of the RPP teachers made a significant contribution to the research discipline and nearly three-fourths made a significant contribution to the output of the professors' laboratories. One-third of the research findings were published and one-fifth were presented before professional research societies. The RPP teachers also scored significantly higher on the Science Process Inventory than did a comparable group of teachers without the research experience.

The effectiveness of an inservice institute in increasing knowledge of content and the ability to understand and use broad concepts in mathematics and science was assessed by Selser (111). As a part of this assessment, the Test on Understanding Science (TOUS) and the Sequential Test of Educational

Progress were administered to 20 science teachers who participated in the institute and to an equal number of control teachers who had not attended the institute. The science teachers who attended the institute made significantly higher scores on both STEP and TOUS instruments than did the control teachers. This indicated a greater ability to understand concepts of science and a greater understanding of the nature of science on the part of the participants.

Chapman (25) investigated the effect of an inservice elementary school science summer institute on elementary teachers' attitudes toward science and understandings about the scientific enterprise, scientists, and the methods and aims of science. The experimental group consisted of those teachers who participated in the institute while the control group was composed of randomly selected elementary teachers in other summer session classes. The TOUS instrument, along with other data collected, was administered to both groups before and after the summer session. Among other findings, it was determined that the experimental group showed a significantly greater change in total score on the TOUS posttest over the pretest than did the control group; that the experimental group showed a significantly greater change in total score on the TOUS posttest compared to the total posttest score for the control group; and that no significant relationships were found between TOUS scores and the variables of hours of college science, life science, physical science and mathematics, years of high school science and mathematics, average college grade, average high school grade, age, or experience. It was concluded that such a summer institute could result in significant changes in science understandings by participants.

Welch and Walberg (133) tested 162 physics teachers who were participants in four different summer institutes with a pre-posttest battery of instruments

which included the TOUS and SPI. Significant gains on TOUS were scored by teachers at three of the four institutes and positive gains on SPI were recorded for all institutes, only the mean gains at two of the institutes were significant however. Success in increasing participants' understanding of *science and scientists was indicated by the findings.*

Similar findings of significant gains in pre-post-test TOUS scores by institute participants were reported by Dean (28) and Southerland (115). Using the Wisconsin Inventory of Science Process (a modification of the SPI), Sutherland (118) also found significant gains recorded by institute participants in pretest-posttest measurements.

Related studies include Brekke (16), Fowler (39), George and Rose (42), Hulleman (55), LaShier (66, 67), Mayer, Disinger and White (76), McCormick (77), Merkle (80), Ost (93), Thompson (122), and Villavicencio (125).

The studies cited included a variety of instruments administered to different populations under different conditions. The overall results, however, suggest that gains were made by most participants. To the extent that the various instruments measured an understanding of science, it appears that the institutes were successful in promoting a better understanding of the nature of the scientific enterprise. It should be noted, however, that changes in scores were often found not to be significantly related to attitudinal changes and were not necessarily indicative of altered teaching behaviors.

Career Effects

Because the teacher was the primary focus of the Institute Program, considerable attention was devoted to attempting to assess the impact of various institutes upon the teaching careers of the participants. Specific concerns were related to determining how many remained in teaching following institute participation, what changes in job mobility occurred, whether or not participants assumed increased responsibility and leadership, and whether professional activities and membership in professional organizations increased.

Brekke (16) reported a follow-up study of participants who had attended institutes at the University of North Dakota over a five year period. He found that few participants left teaching to go into other professions, but some did leave public school teaching to instruct at the college level. He also found that most of the participants remained in the same schools in which they had taught prior to their institute experience, and of those who changed, most remained within the same state and went to larger systems. Although most other studies reported few participants leaving the teaching profession, most indicated greater mobility than that reported in this study. The principals in Brekke's sample were positive in their ratings of participants' gains and improved teaching and also positive, but somewhat lower in their ratings of the extent to which participants sought to assist in developing new instructional and curriculum materials and to assume more responsibilities as consultants and advisors. Brekke found that most participants were encouraged in continuing their education, most indicated that they would continue even without institute support.

Jenkins (59) evaluated the first five AYI's held at the University of Utah from 1957 to 1963 based upon a 90.5 percent response to questionnaires mailed to 243 past participants. Among other findings, it was determined that 71 percent were teaching fulltime in secondary schools, 7 percent were teaching parttime along with counseling or administrative duties, 6.5 percent were administrators or supervisors, 11 percent were teaching in colleges, and 4 percent had left the education profession. The large majority of participants believed they had made improvements in prestige, attitudes, leadership, and professional growth.

The influences on employment status, subsequent academic preparation, and professional image were investigated by Wittwer (134) as one means of evaluating a Research Participation Program at the University of Wisconsin. A structured questionnaire was directed to each of the 87 teachers who had participated in the program at some time during the 1959-1966 period. Approximately 40 percent of the teachers reported changes in their places of employment or job responsibilities since first becoming participants in the RPP. Of these teachers, about 45 percent reported these changes as a direct consequence of their RPP experience. Fifty percent of the RPP teachers returned to graduate school after participating the program and nearly 45 percent indicated that additional graduate credit was earned as a consequence of the RPP experience. As a consequence of their RPP experience, more than half of the teachers joined professional societies and more than 80 percent were influenced to frequently review research journals. More than three-fourths reported a gain in prestige and dignity among their students, colleagues, and administrators. Nearly all reported increased competence, effectiveness, and self-confidence as teachers.

Macon (72), as a part of a study of characteristics and opinions of participants of AYI's held at The University of North Carolina at Chapel Hill from 1968 through 1971, reported several post-institute professional characteristics. Of the 58 respondents, 94.5 percent had earned the M.A.T. degree and 5.5 percent had applied AYI work toward other advanced degrees; 60 percent had attempted additional graduate study. Changed teaching positions were reported by 63.8 percent while 29.3 percent had changed states of employment. Nineteen percent were in educational positions considered higher than high school and 5.8 percent were no longer in education. The number of department heads increased from 8.6 percent before AYI experience to 15.5 percent after. Educational leadership roles since their AYI participation were reported by 48.3 percent. Membership in professional organizations was increased with membership in NSTA nearly doubled following institute experience. Macon concluded that the AYI experience influenced the participants to increase their mobility, leadership roles, professional activities, and professional status.

While the findings varied among the studies, there were areas of agreement. Dyche (30) found participants of summer institutes at the University of Montana from 1961 to 1971 were not influenced to seek careers in business, industry or school administration. Similarly, Gray (44) found that while participants of summer institutes held at the University of Mississippi from 1957 to 1969 had improved their professional status, the majority of the respondents were employed in the secondary schools in 1970. Dzara (31), in evaluating aspects of summer institutes held at the University of Alabama from 1957 to 1962, found that over 90 percent of the participants were still classroom teachers in 1963 and that only three participants had left the educational profession.

While a large percentage of institute participants returned to the classroom, a fairly high degree of mobility was reported in several studies. Bradberry (14), in studying participants of AYI's held at six southeastern universities, found that 148 of 348 respondents were no longer teaching on the secondary level. She also found that approximately two-thirds of the teachers had accepted additional responsibilities, such as department head or curriculum coordinator, since attending the academic year institute. Roye (104) studied modifications of professional characteristics of participants in AYI's conducted at Arizona State University during 1962 and 1963 and found that the experience did not stimulate a desire in the participants to leave the teaching profession. He concluded that the AYI experience seemed to have contributed strongly to participants' dissatisfaction with their prior teaching position and was of significant value in acquiring a new position, which most participants had done by the time of the study in 1968.

The relationship of career effects to institute participation was also an aspect of the following studies: Gibney (43), Heideman (49), Highwood and Mertens (52), Horner (53), Irby (56, 57), Klimas (63), Marshall (73), Martinen (74), Milliken (81), Redburn (100), and Slawson (114).

Based upon the evidence presented, it appears that a large majority of the participants remained in the educational field for at least three to five years following their institute experiences. Job mobility was apparently significantly increased following institute experience. Although a causative relationship cannot be definitely established, it appears that attendance at one or more institutes was a factor in teachers moving from one position to another, from teaching to administration or supervision, or from teaching in an elementary or secondary school to college or university level instruction.

A related factor was continued graduate study which certainly seems to have been increased following institute experience. Finally, increased professional activity as suggested by such indicators as higher frequency of usage of journal and periodical literature and increased membership in professional organizations and societies, also appears to have been related to participation in the Institute Program.

IMPACT ON STUDENTS

As the NSF Teacher Institute Program developed, immediate concern and attention was directed toward the teachers. The effect upon students of these teachers, although one step removed from the Institute Program in the operation of most of the institutes, was a second major focus. As the program was generally envisioned (65), it was intended,ultimately, that student achievement in science should be improved, that attitude toward and interest in science be influenced in a positive direction, and that understanding of science as a way of investigating and learning be increased. As a long range goal, it was desired that more students would elect future science or science related courses of study and careers. Studies related to students will be summarized in the three subcategories: Cognitive Achievement, Attitudes and Interests, and Understanding of Science.

Cognitive Achievement

Of the studies related to student factors, a majority dealt with achievement in science. While such achievement carries with it a connotation of increased understanding of science, the studies cited here will be reviewed, primarily with respect to cognitive achievement and considerations of changes in student understanding of science in a broader sense will be treated separately.

Bricker and LaShier (17) evaluated a CCSSP summer program which involved 47 elementary school teachers and principals in being prepared to teach the Science - A Process Approach (SAPA). Twenty-six of the participants taught SAPA in grades K-3 during the following year. Four sets of competency tasks were compiled from the Competency Measures to measure gains in student achievement over the year. The design provided for pretesting in September 15 control

students and 20 experimental students randomly selected at each grade level from kindergarten through three. Both groups were again tested in May. The Mann-Whitney U statistic was used to test for differences between the groups. It was found that, at all four grade levels, there were no significant pretest differences between the experimental and control groups. Posttests in all four grades, however, indicated that significant achievement differences existed in favor of the experimental group. It was concluded that students involved in the SAPA program consistently achieved more of the stated objectives than did the students in the control group.

A similar study is reported by LaShier and Kurtz (68) on the evaluation of another CCSSP institute conducted at Kansas State Teachers College in 1969-70. Thirty elementary school teachers and five administrators participated in the program which was designed to prepare the participants to implement the SAPA program. In addition to various teacher factors considered, student achievement was evaluated. In the fall of 1969, 108 students were pretested using one of four forms of a Set of Competency Tasks. In the spring, 97 of these same students were given the posttest. The students in this sample population were divided into control and experimental groups based on whether they had received instruction in SAPA. The Mann-Whitney U test was used to determine whether any significant differences existed between the control groups and experimental groups at the beginning of the year and after the experimental group had received instruction in the SAPA materials. The analysis of initial differences between the four pairs of experimental and control groups indicated that only in one of the four pairs of groups did a significant difference exist prior to instruction. In this one case the experimental group outperformed the control group. On the posttest scores,

the analysis indicated that the experimental groups scored significantly higher than the control group in three of the four cases.

Selser (111) assessed the effectiveness of an inservice institute in increasing knowledge of content and the ability to understand and use broad concepts of science and mathematics. As a part of the evaluation, he compared scores of 745 pupils whose teachers had participated in the institute with scores of 761 pupils whose teachers had not attended the institute. Among the instruments used were the Sequential Test of Educational Progress (STEP), Science, Level 3 and the STEP, Mathematics, Level 3. Some of the findings include: science pupils taught by institute participants scored significantly higher on the STEP, Science, than did science pupils taught by the control teachers; and, at the seventh and eighth grade levels, pupils taught mathematics by participating mathematics teachers scored significantly higher on the STEP, mathematics, than did pupils taught by the control teachers; the ninth grade pupils of mathematics participants made higher mean scores than did pupils of the control teachers but the difference was not significant. Selser also found that when the means of the individual grade levels for science and mathematics scores for the STEP tests were pooled, the respective participating pupil groups scored significantly higher than did the control groups.

An inservice program for earth science teachers was evaluated by Mayer, Disinger and White (76) in a study which included an assessment of cognitive growth of students in the classes of participants. To determine this, the Test of Science Knowledge (TOSK) was administered in all classes early in October, 1969 and again in late May, 1970. They found, using t-tests for matched pairs, that TOSK, Part I (Factual Information) means increased

significantly. The difference in TOSK, Part II (Principles), means was positive but not statistically significant. It was indicated that the CCSS Program was successful in helping participants be effective in, among other things, improving student understandings of science concepts and processes.

Behringer (8) examined the modification of biology curricula developed as part of a CCSSP program for use by 35 teachers and 4,264 students. The biology students were grouped into ability levels with the average group using the unmodified BSCS Yellow Version and the slow learner groups and the accelerated group using modified curricula. For experimental design purposes, some classes in each of the low and high ability groups were taught with the unmodified program. The data indicated that gains in learning were significant for all groups; that the differences in achievement between groups using modified and unmodified materials were not significant; and that gains in learning for groups using unmodified materials were significantly greater for the average students than for either the slow learner or accelerated groups, indicating that modifications were desirable for slow learners and accelerated students.

Brekke (16), in evaluating the effectiveness of institute programs held over a five-year span, examined various indicators of student achievement. He found that University of North Dakota admission records based on standardized tests showed a gain of more than ten points in achievement in the science area for students taught by institute participants before and after the teachers' institute experience. He also found that institute-trained teachers had several students admitted to prestige schools noted for rigorous programs in science and mathematics. Non-institute teachers, on the other hand, had none of their students admitted to the same institutions.

Student achievement was also included as a factor in studies by Ahlgren (2), Bingham (11), Bridges, Bingham and Green (18), Howe (54), LaShier (66, 67), Thelen and Litsky (121), Tweeten (123), Uffelman, Magoon, Idstein and Yolles (124), and Villavicencio (125).

Student gains in achievement were reported in nearly all the documents reviewed. The relationship of these gains to teachers attending one or more institutes was not always clear. In at least one study (124), students taught by non-participants scored significantly higher on both pretest and posttest administrations of the American Chemical Society (ACS) test than did students taught by participants. On the whole, however, the evidence suggests a positive relationship between teacher participation in an institute and achievement gains by that teacher's students. It should be noted that other factors such as test bias or knowledge of participation in an experimental program, may influence results, hence a causative relationship is not clearly defined.

Attitudes and Interests

Attempts to assess attitudes and interests have consistently been plagued by the elusive nature of these factors. The studies summarized here reflect this difficulty and present several instances of findings and results at variance with one another.

Bridges, Bingham and Green (18), in evaluating a CCSS Program designed to prepare teachers to teach the DISCUS program, examined the effects on underachieving junior high youths with respect to their knowledge of science, and their attitudes toward themselves, their teachers, and their school. The basic approach underlying the program was that the underachievers were separated from their more successful peers, placed in a success-oriented environment, provided with a series of small group activities, used a directed

discovery approach while carrying on the activities, and used data from their activities in arriving at meaningful concepts via discussion techniques. It as found that the treated groups achieved a better understanding of science, and displayed better attitudes toward themselves, their teachers, and their school than did non-treated groups. Also, the groups taught by teachers trained in the CCSS Program were found to have achieved a better understanding of science, and displayed better attitudes than those taught by non-trained teachers.

A pretest-posttest, nonequivalent control, design was employed by Lauridesen (69) to compare the effectivensss of ISCS Level One with non-ISCS seventh grade science classes in 1) fostering positive growth in the scientific attitudes associated with the nature of scientific laws, the limitations of science, and the desirability of science as a vocation; 2) enhancing the self-reliance level of seventh grade students; and, 3) in elevating the ranking the students gave to science when ranking five classroom subjects in order of preference. Data were collected from more than 650 students in classes of 15 ISCS Level One teachers who had participated in a CCSS Summer Institute at The University of Kansas. More than 200 non-ISCS respondents were in classes of eight non-ISCS teachers each of whom taught in a school district represented by the 15 ISCS teachers. Discriminant analyses were performed on the pr test and posttest data collected with instruments designed to measure scient ic attitudes, self-reliance, and classroom subject preference. It was found that the ISCS group experienced a significant positive increase in the attitude associated with the nature of scientific laws, while the non-ISCS group did not undergo as large a positive change in this attitude. The non-ISCS group experienced a significant negative change in the attitude associated with the

desirability of science as a vocation; the ISCS group also experienced a negative change which was nearly as great. Both groups experienced a non-significant increase in the attitude associated with the limitations of science. Both groups also ranked science lower, but not significantly so, on the preferential ranking of classroom subjects on the posttest than on the pretest. Finally, both groups experienced nonsignificant increases in self-reliance. The findings led to the conclusion that the Level One program has not completely met its objectives.

Spradlin (116), in an investigation of the behavior change of 50 scienc teachers who had participated in a summer institute, studied attitude changes of the teachers' 1240 secondary school students. A Student Semantic Differential was administered at the close of the school year preceeding the summer institute and again following the next teaching year. She found no statistically significant difference in the attitudes of the students toward the world of science, science class, science teacher, science laboratory, or school before and after the teachers' institution participation. There was, however, a positive trend which, it was suggested, could become more positive as the teachers grew more secure in the use of new activities.

Ost (93), as part of the evaluation of an institute for biology teachers, investigated the difference in the preference of the students of the institute participants for biology, before and after attending the institute. The Subject Preference Survey was administered to the participant's first biology class of the day during April preceeding the participant's attendance at the institute and again six months after the institute. No significant difference between pretest and posttest scores was found, suggesting that students in science classes of institute participants neither increased nor

decreased their preference for the science course. It was noted that although an immediate change in student preference was not detected, the results did not preclude the possibility of a long-term effect.

Thompson, Irwin, Bauman and Sanders (122) analyzed data from questionnaires administered to three randomly selected students in each class of a randomly selected sample of one-third of the participants from each of 26 ESCP institutes. Among the results reported, the majority of the students felt their earth science course was worthwhile and 64 percent were more interested in earth science at the end of the year than at the beginning.

Studies dealing with students' interest in future career choices yielded contradicatory results. Brekke (16), in a followup study of participants who attended NSF institutes at the University of North Dakota, reported some comparisons between students of institute and non-institute trained teachers. He found that in-titute participants reported a proportionate gain of eight percent in the number of students going on to college from one year to the next (comparing graduates before and after teacher's institute attendance) who enrolled in courses in science and mathematics fields. Non-institute trained teachers reported a gain of six percent from one year to the next of students enrolling in college for science and mathematics careers. Positive results were also indicated by Slawson (114), who attempted to determine and analyze the impact and influence that participation in AYI's at the University of Virginia had on former science participants. One of his conclusions was that the AYI Program had had a positive effect on the former science participants in terms of ability to motivate students toward careers in science. Jenkins (59), however, in evaluating the AYI Program at the University of Utah, concluded that the overall effects of the program towards the goal of influencing more students to choose scientific or mathematics careers were negative.

Additional studies which considered attitudes and interests include those reported by Ahlgren (2), Bartlett and Edgerton (6), Bogen (13), Bruce and Parakh (22), Dean (28), Klimas (63), LaShier (67), and Roye (104).

Any positive relationships between the teacher intitute program and increased interest in, or improved attitudes toward, science on the part of students of participants cannot be supported on the basis of the studies reviewed. On the other hand, neither can negative changes in student attitudes or interests clearly be attributed to teacher participation in the institutes.

Understanding of Science

A number of studies examined the science achievement of students from which some inferences about the students' understanding of science might be drawn with respect to a specific area. Very few studies dealt with the understanding of science in the broader sense of considering the nature of the scientific enterprise.

Bruce and Parakh (22) reported on the evaluation of a Research Participation Program conducted at Cornell University during 1963-1964. As a part of this study, they evaluated the effects attributed to the program on 51 student assistants. One form of evaluation involved the use of rating forms completed by participating scientists, teachers and student assistants. All three groups rated the students high on general interest. Student contributions to problem solving and value of suggestions were both rated fair to good by all three groups. A high rating was given by all three groups to items concerning noticeable increases in scientific attitudes and critical thinking on the part of the students. A second form of evaluation was the administration of the TOUS instrument to 46 matched pairs of student assistants and non-participating students. The test was given twice, first early in the

program and again near the end of the program. A test for homogeneity of variance on pretest scores revealed no significant difference between the groups, suggesting that the students were well matched on their original understanding of science. The mean gains in score, for total as well as subscales, by the student assistants were not significantly different from the mean gains in score by the matched non-participating students. It was noted, however, that total scores on the first test were high, about half the students scored at or above the 90th percentile, suggesting that a ceiling effect was in operation.

LaShier (67), in evaluating ACCSS Project for ISCS teachers, studied a series of factors related to student achievement, attitudes and understanding. Based upon their progress and scores on achievement tests, the ISCS students were separated into high achievers and low achieving by selecting the top third and bottom third, respectively, of the group. The instrument used included measurement of student attitudes toward science as an approximation to truth, and science as an empirical discipline. Significant differences were found in scores achieved by the two groups on both measures. It was concluded that high achieving ISCS students had a significantly better conception of science as approximate and changeable than did low ISCS achievers. Similarly, the high achieving ISCS students had a significantly better grasp of science as empirical, or based on natural phenomena, than did low achievers.

Ahlgren (2), in an interim report, summarized various aspects of the evaluation of Project Physics including student gains on TOUS and SPI. A random sample of 100 teachers were selected from a list of 16,911 high school physics teachers. Of the 70 who agreed to participate, 40 teachers were randomly selected to teach Project Physics and 30 to teach as they would have ordinarily taught. Among other instruments, TOUS and SPI were administered

to the students on a pretest-posttest basis. It was concluded that the Project Physics scored higher on both TOUS and SPI than they would have if they had been in the control group classes.

Other studies dealing with students' understanding of science include Bingham (11), Bridges, Bingham and Green (18), Dean (28), Mayer, Disinger and White (76), Selser (111), and Villavicencio (125).

As is apparent from the studies described, the findings related to students' understanding of the nature of science were not consistent. Moreover, because most of the studies dealt with this concern in a descriptive manner, clearly defined relationships are few. In general, it appears that students whose teachers had had institute experience were likely to have a somewhat better understanding of science than were students of non-participants. However, it is by no means certain that such a difference was significant.

SUMMARY

In summarizing the results presented in the studies reviewed, the summaries of findings with respect to teachers and to their students will be examined in an attempt to determine the probable impact of the NSF Teacher Institute Program.

The studies which examined the characteristics of participants, rejectees, and non-applicants suggest that, in general, the institute participants were those who most likely were the better qualified teachers while the non-applicants were more likely to be the least qualified. On the surface it appears to be a case of the rich, educationally, getting richer. But the participants were also those teachers who tended to teach more science courses, have contact with more students, be more active in professional and leadership roles, and who were most likely to remain in teaching. On the basis of the characteristics and selection of participants, then, it must be concluded that the effect of the Institute Program was positive.

Several studies noted that participation in teacher institutes was the most important factor in increasing the content background of teachers. In this respect there was agreement by teacher-participants, administrators and supervisors, and college and university personnel. Based upon the evidence presented, there was virtually unanimous agreement that the participating teachers' subject matter competence had been significantly improved and that the Institute Program had clearly been successful in this regard.

Changes in teacher attitudes were investigated in several studies with highly mixed results. Positive changes were found in several instances, and in some cases these appeared related to some aspect of the institutes. However, enough findings of no-significant-difference or of negative changes, together with findings of uncertain relationships between attitudes and

institute experience suggest that any conclusions drawn would be so tenuous as to be of little value. It is nonetheless clear that the majority of the participants had positive attitudes toward their institute experience and viewed the results as beneficial.

A large number of studies investigated changes in teacher behavior following institute participation. Based upon the findings reported, it appears that there were changes and these changes tended to be in the direction desired by the institutes. While the fact that the better prepared, and thus probably the more capable, teachers were most likely to be selected as participants cannot be discounted, it appears that the Institute Program was probably a causative agent in bringing about improved teaching behavior. The permanence of such improvement is not, however, established.

In the area of teachers' understandings of the nature of science considerable variation was found in instruments used, populations assessed, and reported results. Based upon the assumption that the instruments administered did measure, to some extent, an understanding of the aims, methods, and processes of science, it appears that significant improvement did occur on the whole. The relationship of this change to the institute experience of the teachers is not clear. Because institute participation was one of the few factors common to all the studies, it seems reasonable to conclude that the Institute Program was a positive factor in this effect.

With respect to the effects on the careers of teachers, it appears that several changes occurred following participation in the Institute Program. Although relatively few left the education field, the teachers did become more mobile, moving from one position to another, from elementary or secondary to college levels, from teaching into administration or supervision. As a

group they also exhibited an increase in continued graduate study, in professional activities, and in educational leadership roles after attending institutes. While again a causative relationship cannot be definitely concluded, it appears that the Institute Program had a positive effect on the careers of participants.

Studies of student achievement reported gains in most instances. Whether or not these gains can be ascribed to attendance in an institute by the teachers, however, is not at all certain. Although in most cases gains were noted for students of participants, the gains were not always significantly different from gains scored by students of non-participants. In at least one case the non-participants' students outscored the participants' students. A critical factor in studies of the kind reported here is the appropriateness of the instruments used. A conventional or traditional instrument applied to students who have been taught in a manner intended to be different from the conventional or traditional manner may well score lower than a control group. Obviously, the converse would be equally true. Even the knowledge that they were participating in an experimental program could influence students in such a way as to alter achievement test scores. Because factors such as those cited appear to be potentially significant, any relationships between the Institute Program and student achievement in science remain unclear.

Student attitudes toward, and interest in, science were the basis for several studies. The findings, however, were at variance with one another. All three conditions, positive changes, negative changes, and no changes, were reported. No general relationship between changes, or lack of changes, in student attitudes or interests and teacher participation in an institute can be determined.

Studies related to student understanding of the nature of science were very few in number and generally descriptive in nature. The findings reported were not consistent and do not support any well defined relationship between teacher institute experience and student understanding of science. While the studies suggest that students of participants were likely to have a somewhat better understanding of science than were students of non-participants, the difference cannot be considered significant nor necessarily attributable to the Teacher Institute Program.

In reviewing the overall impact of the Teacher Institute Program, it should be noted that the studies reported are representative of the studies done rather than an exhaustive compilation. Because it is a fairly extensive sample, the results reported can be expected to present a reasonably accurate view. In conclusion, while there are areas where data were scant and where results were not definitive, the National Science Foundation Teacher Institute Program appears in general to have been successful in making a significant, positive impact on science education.

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